No. 68 May 1996

# solplan review

*the independent journal of energy conservation, building science & construction practice*

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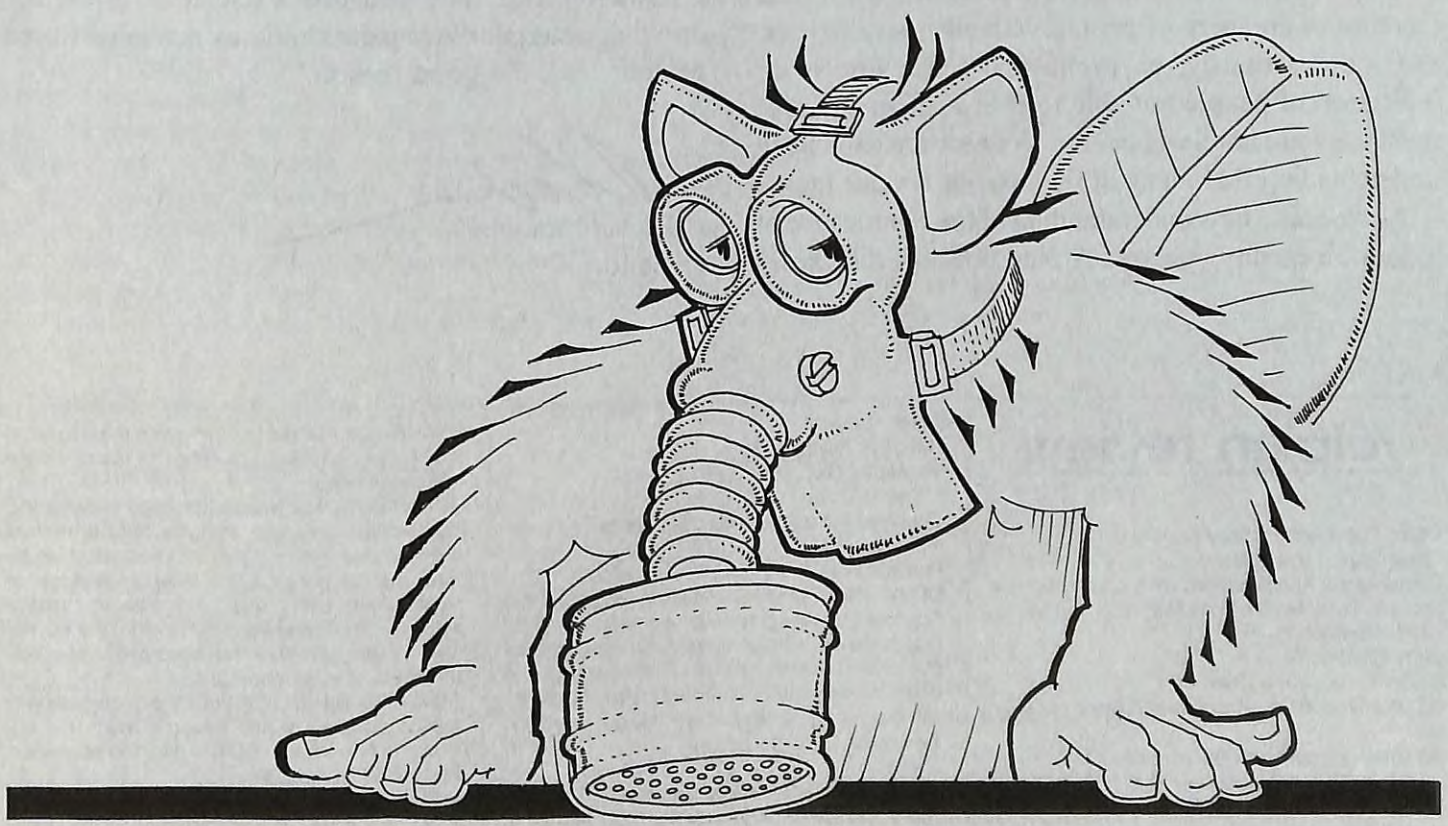
# Indoor Air Quality



## From the Editor . . .

This issue we focus on an area of understanding that has entered our consciousness only recently: the quality of the indoor environment. It used to be that the smell of newness was a sign of quality; the fresh smell of new paint and synthetic finishes was expected. We've now realized that it's not that simple. The "new" smell, whether it be a house or car, is in fact the mark of a chemical soup. We now understand that it can be harmful to our health and to the environment.

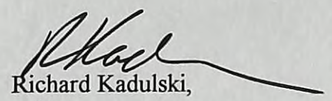
Only a generation ago Rachel Carson pointed out in her book *Silent Spring* the implications of our ever increasing reliance on chemicals. Progressively, the build up of chemical pesticides starts to affect living organisms. As they work their way up the life chain, faster than evolutionary changes can take care of them, the impacts are increasingly more significant.

It may have sounded like science fiction only a few years ago, but now the medical people are telling us that microbes (with a short life span) have already mutated to the point that there are no ways to control them. The increase in numbers of people with allergies, asthma, and more seriously, environmental sensitivity, is an indication of people not able to deal with an environment we were not designed for. We now are gaining an understanding that many of the reasons are our fault.

As we gain a new understanding of the significance of indoor air quality, we are learning not only the causes and appropriate limits, but also that there are alternatives. A clean, healthy environment does not mean that we have to make sacrifices. It's not just a luxury for those that can afford to spend a lot of money. Whatever the budget, there are appropriate alternatives available, but it does require that attention be given to materials selection.

The consequence of not considering the environmental impacts means an ever deteriorating environment, both indoors and outdoors, and increasingly poorer health. The reason so many of us feel so much better in the spring is not just the optimism of the reawakening in spring, but also because we start to spend more time outdoors, where the air quality is superior to that found indoors. The build up of indoor toxins has a chance to clear out of our system.

If we are to leave a legacy to future generations, we cannot turn back on the steps we've started to make. I know that many will grumble, saying it's a bunch of codswallop. But hey, you don't use lead pipes for drinking water, nor lead paints and raw asbestos fibres anymore, and for good reason.



Richard Kadulski,
Editor

**solplan review**
the independent journal of energy conservation, building science & construction practice

Editor-Publisher: Richard Kadulski
Illustrations: Terry Lyster
Contributors: Ann Charlton, Bill Walker, Michael Kronick, Tom Hamlin, Ross Monsour, Tim Mayo, Terry Robinson
ISSN: 0828-6574
Date of Issue: June 1996
SOLPLAN REVIEW is published 6 times per year by:
the drawing-room graphic services ltd.
Box 86627, North Vancouver, B.C. V7L 4L2
Tel: 604-689-1841 Fax: 604-689-1841
e-mail: solplan@cyberstore.ca

Street address:
208-1280 Seymour St.
Vancouver, B.C. V6B 3N9

Canadian Publications Mail Product Sales Agreement No. 454532
Postage paid in Vancouver, B.C.
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SUBSCRIPTIONS: In Canada 1 year $40.66; 2 years $77.04 (includes GST). USA and other foreign payable in US $ 1 year $46.00, 2 years $88.00.

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# Indoor Air Quality

Indoor air pollution has been rated by the U.S. Environmental Protection Agency as one of the top five most urgent environmental issues, accounting for more than $1 billion annually in direct health care costs and as high as $60 billion per year in lost productivity in the U.S.A.

Employers, building owners, health insurers and financial institutions now recognize that "sick" buildings not only erode people's health and vitality, but can also decrease productivity, increase health costs and liability and reduce building values. The World Health Organization estimates that one third of all new and remodelled buildings have unhealthy air. Solving or avoiding indoor pollution problems requires diversified expertise.

Indoor air should be sufficiently free from biological, physical and chemical contaminants to ensure there is little risk to the health and safety of the occupants. Some contaminants found in buildings are a concern because they have carcinogenic effects. Others are not carcinogenic, but they still negatively affect human health.

What does good indoor air quality mean? What are acceptable limits for contaminants - be they man made chemicals or naturally occurring substances? Health officials look at long term and short term exposure.

The acceptable *long-term exposure* is the concentration to which a person may be exposed over a lifetime without risk to health. The acceptable *short-term exposure* is that concentration to which a person may be exposed over a short period without undue risk to health.

Two compounds are often used to provide a general indication of indoor air quality: carbon dioxide and water vapour.

### Carbon Dioxide

Carbon dioxide ($CO_2$) is produced by people and animals. Indoor concentrations can be reduced only by ventilation. Caution must be used when interpreting carbon dioxide concentrations as a general indication of residential indoor air quality. $CO_2$ is useful as an indicator of general air quality only in buildings where there are significant metabolic or combustion sources of carbon dioxide. Otherwise $CO_2$ levels will be low over a wide range of ventilation rates (for example, in large houses with only one or two occupants and no unvented combustion appliances).

The atmospheric concentration of $CO_2$ is about 350 ppm. Levels of about 1000 ppm are an indication of not enough fresh air.

### Water Vapour

Water vapour is another indicator of air quality, as it usually tracks occupancy patterns. Changes in occupancy throughout the day affect the rate at which water vapour is generated, while other pollutants are generally produced constantly from materials and furnishings. The variation in indoor relative humidity changes over the year, so control has to be variable.

The control of indoor air pollutants other than water vapour by ventilation systems may not be satisfactory because in a large house with a low occupancy, humidity will be controlled, but it may not be adequate to handle other pollutants.

## Guidelines and Recommendations

### Substances with Exposure Guidelines

**Carbon monoxide** (CO) is an odourless gas produced by combustion. In the body, it reduces oxygen supply and at high enough concentrations will lead to death. Every year several people die of CO poisoning - last year there were a number of such cases in Saskatoon when furnace flues iced up and combustion gasses spilled into the house.

**Nitrogen dioxide** ($NO_2$) is the only oxide of nitrogen that has been shown to be detrimental to human health at concentrations that may be encountered in indoor air. The primary outdoor sources of nitrogen dioxide are vehicular and industrial emissions. Gas stoves and unvented combustion appliances are major sources of nitrogen dioxide indoors.

In North America, the background level of nitrogen dioxide in rural areas is less than 0.010 ppm but in urban centres, $NO_2$ levels are at least double this value. Families living in rural or low-pollution areas and who use gas for cooking are exposed to indoor nitrogen dioxide levels of roughly 30 $\mu g/m^3$ (0.015 ppm), although average concen-

| Indoor Exposure Guidelines | | |
|---|---|---|
| Compound | Long term exposure limits | Short term exposure limits |
| Carbon Dioxide | 3500 ppm | |
| Carbon Monoxide | 11 ppm (8 hours) | 25 ppm (1 hour) |
| Nitrogen Dioxide | 0.05 ppm | 0.25 ppm |
| Ozone | | 0.12 ppm (1 hour) |
| Particulate matter (0.1 - 10 um) | 40 ug/m3 | 100 ug/m3 |
| Sulphur Dioxide | 0.019 ppm | 0.38 ppm (5 min) |
| Formaldehyde | 0.05 ppm | 0.10 ppm |

trations of 100 µg/m³ (0.050 ppm) have been recorded in some homes.

**Ozone** is an irritant that can cause coughs, chest discomfort and irritation of the nose, throat and trachea. Ozone causes detrimental effects on the lung function of healthy people at concentration above 0.30 ppm. It can be detrimental to the lung function of healthy people engaged in strenuous physical activity at concentrations lower than 0.30 ppm.

**Airborne Particulate Matter** is a mixture of physically and chemically diverse substances. Numerous epidemiological studies have indicated that health improves as concentrations of airborne particulate matter decrease.

Particle size is of concern for health. The critical size is from 0.1 to 10 µm in diameter, smaller particles are generally exhaled, larger particles (above 15 µm) are too large to be inhaled.

Indoor concentrations of fine particulate matter tend to be higher than those outdoors. Cigarette smoke is the most significant indoor source of particulate matter.

**Sulphur Dioxide** is the main oxide of sulphur found in indoor air. Indoor concentrations are generally lower than outdoors as most sources are outdoors, and sulphur dioxide is readily absorbed by furnishings and fabrics.

**Water Vapour** Based on health considerations, the optimum relative humidity levels in indoor air are 30% to 80% RH in summer; 30% to 55% RH in winter.

**Formaldehyde** is a colourless gas with a pungent odour. It is easily absorbed onto surfaces and textiles. It is a naturally occurring compound, and is also used in many manmade products, including particleboards. Formaldehyde gas is a sensory irritant, mainly affecting nasal passageways, respiratory tract, and the eyes.

**Radon** is a naturally occurring soil gas with a short life span. When radon molecules decay, they form short lived unstable radioactive particles. They will attach themselves to any available surface, which can include the bronchial passages when inhaled, resulting in a risk of lung cancer. Radon concentrations indoors are normally higher than outdoors (usually in the basement, as a result of soil gas leakage).

Radon is not a concern in some geographical areas, due to local geology.

The Action Level, which is the concentration at which remedial action should be taken is 800 Bq/m³ as an annual average concentration in the normal living area.

**Biological Agents** include a whole range of bugs and criters; some are more dangerous than others. There is no simple measure of acceptable limits. The best solution is to reduce conditions that allow these things to grow. This means measures should be taken to ensure that:

- excess humidity and condensation are not present;
- surfaces are kept free of dust;
- stagnant water sources, such as humidifier tanks, are kept clean and occasionally disinfected.

Many of these are homeowner maintenance issues, but the design and construction of a home can make it easier for the resident to avoid problems.

**Consumer Products** can introduce a wide range of pollutants. Safe, vented storage spaces should be considered in the design of new homes.

**Chlorinated Hydrocarbons** Large quantities of chlorinated hydrocarbons are produced and used annually worldwide. They are present in the home environment principally as solvents, cleaners and aerosol propellants, and some individuals may be exposed to relatively high concentrations. In some cases, chlorinated hydrocarbons may be released continuously from household products; they have also been detected in drinking water.

**Pest Control Products** Exposure to pest control products in the home can occur both by inhalation and by absorption through the skin (for example, following contact with pesticide-treated surfaces.) Pesticides may also be ingested following injudicious use in the vicinity of foods.

**Polycyclic aromatic hydrocarbons (PAHs)** are a large class of organic compounds produced when materials containing carbon and hydrogen are burned. Woodburning is the principal source of PAH's. Some are known to be carcinogenic.

**Tobacco smoke** is a complex mixture of substances. In view of the carcinogenic properties of tobacco smoke, it is recommended that any exposure to tobacco smoke in indoor environments be avoided. ☼



# A Builder's Guide to Selecting Building Materials

## Making Informed Choices to Improve Indoor Air Quality

### Emission Rates and Concentrations: The Confusing World of Units

The emission of pollutants from building materials is a very complex process based on a number of interior environmental factors. However, emissions are usually evaluated in environmental chambers under controlled conditions which may not always reflect real life situations.

### Emission Rates

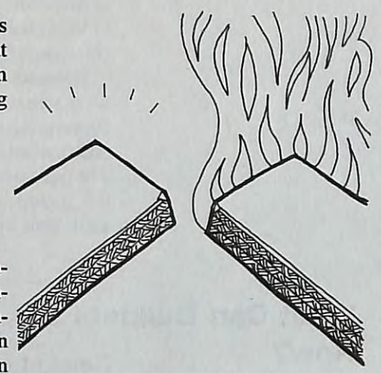
The rate at which pollutants are being emitted from a material is expressed as the quantity of pollutant (usually in milligrams, mg, or micrograms µg) per area of material (usually in square metres, m²) per time (usually in hours, hr). So a typical emission rate could look something like: 0.35 mg/m² hr or 350 µg/m²hr. (A microgram is 1/1000th of a milligram).

Emissions are sometimes expressed as the pollutant concentration which results from an emissions test in an environmental chamber after a certain period of time, using an amount of material similar to a real building and under specified conditions (air change rates, temperature, humidity). Such concentrations can be expressed as the quantity of pollutant (in milligrams, mg, or micrograms, µg) per volume of air (usually in cubic metres, m³) and would look like this: 0.2mg/m³ or 200 µg/m³

Concentrations can also be expressed in parts per million (ppm) or parts per billion (ppb), as is often the case for formaldehyde. For example, Canadian particle board is tested against a maximum formaldehyde concentration of 0.3 ppm, which is roughly equal to 360 µg/m³.

### Volatile Content

"Wet" materials, such as paint finishes, sealants and adhesives often have their emissions expressed as the total content of volatile compounds (usually in grams, g) per volume of material, not including water (usually in litres, L). For example, the EcoLogo requirement for the maximum VOCs in water-based paints is 250 g/L. Knowing the volatile content does not help in determining emission rates, but can be useful in comparing similar products.



### Converting From Emission Rates to Pollutant Concentrations

For materials with long-term, relatively constant emissions, such as composite wood products, a simple equation can be used to relate emission rates to pollutant concentrations in either a test chamber or a real building.

$$\text{emission rate} = \frac{\text{pollutant concentration} \times \text{air change rate}}{\text{material loading ratio}}$$

For materials with rapidly decreasing emissions, such as paints, more complicated equations are necessary.

### Emission Rates Vary With Time

Emissions from wet materials, such as paints, are very high immediately after application, but then drop quickly. Emissions from dry materials, such as composite wood panels, decline more slowly. It is not possible to add emissions together without knowing when the emission rates were measured.

Some materials absorb emissions from other materials. Porous, rough or fleecy materials can act as "sinks," absorbing pollutants from the air and then releasing them later. Carpet and drywall are two of the most important sinks in a typical house. Composite assemblies made up of several products behave differently than individual materials.

### Pollutants to be Concerned About

There are hundreds of different chemical compounds emitted from building materials. Unfortunately, health data is available for only a few. The two pollutant groups most commonly encountered in residential indoor environments are volatile organic compounds and formaldehyde.

Volatile organic compounds (VOCs) normally exist as liquids or solids, but vaporize easily, becoming gasses. Because of the difficulty in measuring and identifying so many compounds, the concept of total volatile organic compounds (TVOC) is often used, based on the sum of the most common VOCs.

Research has demonstrated that there are always irritation and discomfort effects when the concentration of TVOC exceeds 3 mg/m³ and no effects when the TVOC level is less than 0.2 mg/m³. The typical level in new Canadian homes is about 0.6 mg/m³. At present, there are no Canadian guidelines for TVOC.

Formaldehyde is emitted from new formaldehyde glues in wood products. It is a respiratory and eye irritant.

Chlorinated hydrocarbons can irritate eyes and lungs, and can damage skin, liver, kidneys, and the nervous system.

Polycyclic aromatic hydrocarbons (PAHs) are primarily associated with combustion and tobacco smoke. Some are cancer causing.

Styrene is emitted from latex backings on carpets and foamed or synthetic products. It irritates eyes and nose, can cause nausea and is a suspected carcinogen. 4-phenylcyclohexene (4-PC) is released from carpet latex backing and is what gives new carpet its characteristic odour.

## What Can Builders Do Now?

### Select Low-Emission Materials

**Data:** Builders should continually ask manufacturers and suppliers for emissions data on their products and work with them to develop lower-emission alternatives.

**Labelling:** Voluntary labelling programs should be supported by asking for and selecting materials which have met Green Label, EcoLogo and other program criteria.

**Focus on priority areas:** Large interior surfaces, such as floor coverings, cabinetry, and paints and finishes have a correspondingly large impact on the surrounding air. Low emission products should be chosen wherever possible.

**Floor Coverings:** Choose carpets with latex-free backings. Natural fibre (e.g.. wool) carpets and nylon carpet tiles have lower emissions. Avoid carpets with chemical treatments. For carpet under cushion, jute, felt, polyethylene and cork offer alternatives to latex.

**Linoleum or Composite Vinyl Tiles:** offer lower emissions than sheet vinyl. Relatively inert - although more expensive - flooring alternatives include ceramic tile, hardwood and terrazzo.

**Paints and Finishes**: Zero-VOC paints are now available. All interior paints used should be water-based.

**Composite Wood Products**: Formaldehyde-free medium density fibreboard (MDF) is available. Phenol-formaldehyde or MDI bonded panels and cement-bonded particle board or fibreboard represent alternatives to conventional particle board and MDF.

**Adhesives, Sealants and Fillers**: Acrylic latex and polyvinyl acetate adhesives are recommended. Water based contact cement and low toxicity adhesives are available. Preferred caulks include water-based, acrylic latex and neutral-cure silicone. Gaskets should be PVC or urethane. Choose grouts with the least odour and allow them to fully cure before occupancy. Low-toxicity gypsum joint compound is available.

### Adopt Construction Strategies to Lower Emissions

**Protect Materials From Contamination**: In particular, protect carpeting from spills during construction and remodelling, and have a no smoking policy on the jobsite - especially once drywall installation starts.

**Seal Emitting Materials** for a few days before installation.

**Air Out Materials** Increase the ventilation during construction and renovation to the maximum possible before occupancy.

**Educate Homeowners on Their Role in Controlling Emissions** What the homeowner brings into the house can be bad - and it's beyond your control. Educate homeowners about indoor air quality and household emission sources. Emissions from furniture and furnishings can originate from composite wood products, fabrics and fabric treatments, vinyls and finishes. For example, the homeowner's furnishings in the Ottawa Innova House more than doubled the concentrations of VOCs.



Instruct the homeowners on the importance of using their ventilation system to maintain good indoor air quality.

**Home Office Equipment** such as photocopiers, laser printers and fax machines can be major sources of contaminants. If the house design includes a home office, provide a quiet exhaust ventilation system from the office area.

For more information on ow-emission materials

***Building Materials for the Environmentally Hypersensitive*** *CMHC Publications*
*Tel: (800) 668-CMHC; Fax: (800) 463-3853*
***Environmental by Design*** *($24.95)*
*Box 95016; South Vancouver, C.S.C, Vancouver, B.C. V6P 6C4*
***Environmental Choice Program*** *(EcoLogo) Certified Products and Services; TerraChoice Environmental Services Tel: (613) 952-0264 Fax: (613) 952-9465*
***Healthier Indoor Environments: Canadian Sources of Residential Products and Services*** *Canadian Housing Information Centre; CMHC Tel: (613) 748-2367; Fax: (613) 232-8214*
***R-2000 Procurement List;*** *Canadian Home Builders' Association; Tel: (613) 230-3060 Fax: (613) 232-8214*
***E-House Indoor Air Quality Product Guide*** *(US $50.00) E-House Environmental Building Consultants Tel/fax: (215) 663-1611*
***The Healthy Household: A Complete Guide for Creating a Healthy Indoor Environment*** *(US $17.95) The Healthy House Institute 430 Sewell Road; Bloomington, IN 47408*
***IAQ Product and Service Guide*** *(US $75.00) Cutter Information Corp Tel: (800) 888-8939 Fax: (617) 648-8707*

***Voluntary Labelling Programs***
*Green Label Carpeting: The Canadian Carpet Institute (CCI)*
*Particleboard Program: The Canadian Particle board Association (CPA) formaldehyde tests program*
*Envirodesic Certification Program (see nest item)*

## Certified Buildings, Products and Services for Healthier Indoor Environments

ENVIRODESIC™

Today's buildings contain an estimated 1,500 hazardous compounds made from about 3,000 synthetic products. Even low levels of pollutants emitted by these products can affect human health over a period of months or years.

As interest in indoor air quality and sick building syndrome has mounted, so has the number of product claims. On the one hand, there are now more options than ever before for improving indoor air quality, and they are becoming increasingly affordable. On the other hand, it is becoming more difficult to sort through the many claims to find those options that can really make a difference.

You want to do the right thing, and wherever possible you want to use products and services that contribute to healthier indoor environments. Still, how do you know what products are the right ones to use?

This is where labelling and certification programs come in. Just having a label saying it is green or healthy is not enough. You must know what the label really means. The EcoLogo program, for example, is focused on environmental concerns (resource efficient use of materials during manufacture, use of recycled raw materials, etc.). However, the emissions standards will vary from product to product.

A new certification program has been launched by a group of consultants in low-pollution design, toxicology, medicine, indoor air quality, marketing and related areas and with the partnership of The Lung Association. The **Envirodesic™** Certification Program is administered by Green-Eclipse Incorporated. It is a trademark licensed to qualified builders, manufacturers and service providers whose products and services meet stringent standards for healthy indoor environments.

Envirodesic certification identifies cleaner products, healthier buildings and expert services that promote healthier indoor environment.

"Since most of us spend about 90% of our time indoors that is where the air could have the biggest impact on your health," says Ian Morton, Program Director for the Lung Association's C.A.N. DO - The Movement for Clean Air Now. "Indoors is also where people can do the most to improve the quality of the air they breathe."

The C.A.N. DO Program, funded in part by Health Canada's Healthy Environment Program,

gives people practical tips for improving indoor air. " We realized quickly that to be effective we had to help people find the appropriate buildings, products and services," says Morton.

## Certification Features

Envirodesic certification means in general that human health has been taken into account in the design of a building, product or service, and that in very specific measurable ways, the building, product or service creates a healthier indoor environment for its users.

As such, Envirodesic certification is tailored to the specific type of building, product or service, and is dependent on the expertise of the certifying body to decide, in as wide as possible a context (a "systems" point of view), whether a given building, product or service can qualify as an effective contributor to a healthy indoor environment.

Because each category is different (e.g., single family homes, building insulation, household cleaners) there is no blanket specification of the features that every building, product or service must exhibit before it is certifiable. Certification is a highly descriptive process, rather than a simple pass/fail judgement based on absolute limits in a single factor such as emissions. Within each category, different buildings, products or services may be certified for different features depending on the intended market. For example, different standards would apply to Envirodesic homes for the general public market vs. a custom Envirodesic home for a highly chemically susceptible individual or family. In addition, within each category, different products may be certified for different features depending on the application (e.g., high efficiency air filtration devices for a hospital setting, vs. medium efficiency filtration for a residential setting).

In general, products must be either non-emitters or low emitters of indoor contaminants, e.g., volatile organic compounds (VOCs). Levels of each identifiable emission product must be within published exposure standards suitable to the application.

Right now, only a few products have been labelled under this program.

*For more information*
***C.A.N. DO Program** Director, The Lung Association, Toronto, Ontario*
*Tel: (416) 864-9911; Fax: (416) 864-9916*
*e-mail: lung@pop.web.apc.org*
***Green-Eclipse Incorporated,** Goodwood, Ontario Tel: (905) 649-1356*
*Fax: (905) 649-1314*
*e-mail: bruce.small@canrem.com*

## Carpet Adhesive Labels

CRI IAQ Adhesive Testing & Labelling Program Criteria (not to exceed):

TVOC
10mg/m².hr at 24 hours
Formaldehyde
0.05 mg/m².hr at 24 hours
1-Hexanol, 2-ethyl
3 mg/m².hr at 24 hours
Report 3 highest remaining chemicals at 24 hours

The Carpet and Rug Institute (CRI) Indoor Air Quality Carpet Testing Program has been extended to include adhesives used with carpets. The testing and labelling of adhesives are a follow-up to the US Environmental Protection Agency's Carpet Policy Dialogue, designed to reduce indoor pollutants.

Adhesives that meet emissions criteria for low VOC's will be identified by a green and white label on the product package. The adhesive label is consistent with the carpet label, and will read CRI Indoor Air Quality Adhesive Testing Program. The program includes ongoing testing of approved products four times annually to ensure that they continue to meet the program criteria.

*Information: Canadian Carpet Institute*
*Tel 613-232-7183; Fax 613-232-3072*

## TVOC's

Building investigations often include air sampling for volatile organic compounds (VOCs) and express the results as Total VOCs (TVOCs). Researchers at Lawrence Berkeley National Laboratory (in California) say that recent studies show that measuring only TVOCs might not tell much - except as a screening tool.

Differences among the various methods for measuring TVOCs under the same conditions will give different results, sometimes by as much as 50%. The chemical composition of the VOC mixture is perhaps more important than the concentration because different mixtures will evoke different responses among occupants.



## Residential Indoor Air Quality Investigator Course

CMHC has developed an indoor air quality inspection procedure for residential inspections.

A three day-indoor air quality course, the first step in CMHC's indoor air quality (IAQ) investigator training program will be delivered next month. The second step will be an apprenticeship. Upon successful completion of the course and apprenticeship, a diploma will be provided to graduates. Those who successfully complete the program will qualify for inclusion in a listing of Canadian residential IAQ investigators.

The IAQ investigator course, will give the participant a good understanding of the types of indoor pollution problems found in homes, the health impact of these problems and their solutions. The course includes a site visit to a house where participants will learn how to use the IAQ inspection procedure.

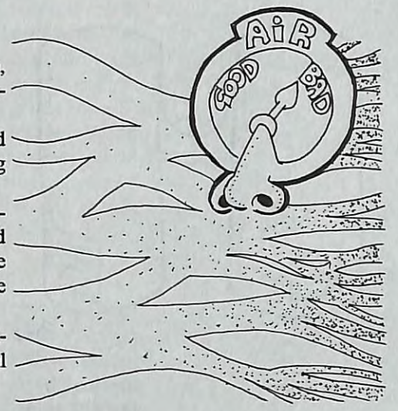
Participants will learn how to set priorities, remediation measures, what advice to give homeowners and how to write reports. The session will also discuss client-investigator relationships, liabilities, conflicts of interest, professional fees and codes of practice.

The apprenticeship will enable trainees to learn and improve their skills in conducting IAQ investigations and will cover the investigations of four problem houses. Successful completion of the program is based on demonstration of competence.

### Entry-level requirements

To qualify for this program, candidates must satisfy these requirements:

- building science background and/or building or renovating experience;
- completed R-2000 builder workshop and HRAI designer and installer courses (or will have completed these courses before the apprenticeship);
- must have good analytical, communication and interpersonal skills.




Potential conflicts of interest will be evaluated. Only nonsmokers need apply. Space is limited to fifteen participants.

*One-day Information Session - July 8, 1996*
*Three-day Investigator Course - July 9 - 11, 1996 (both in Toronto)*
*For Information: Canadian Housing Information Centre Fax: (613) 748-4069;*
*Tel: (613) 748-2367*

## Did you know?

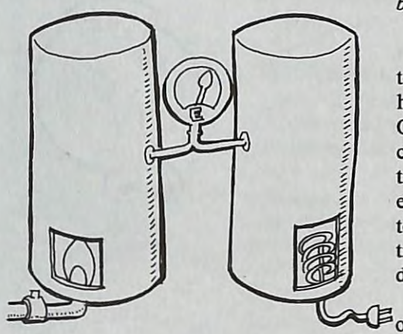
Every time a single-family house is demolished, 90 tonnes of waste are generated - the equivalent of 112 years worth of household waste produced by one person. When a new house is built, another 2½ tonnes of waste is created during its construction.

Where recycling is done, it is largely confined to concrete, asphalt and gypsum. Wood waste, which represents more than 1/3 of all demolition, land clearing, and construction waste, is recycled at a low rate (less than 6% in the Greater Vancouver region).

## Tax-Exempt Energy Conservation Materials

Energy conservation materials are exempt from provincial sales tax in B.C. The biggest item in this category is insulation. Effective May 1, the B.C. Ministry of Finance has expended the list of qualifying products to include polystyrene forming blocks. (These remain permanently attached to the concrete and serve as the primary insulation for the completed building.)

# Comparing Electric & Gas Hot Water Tanks



*by Bill Walker*

As a landlord, I recently went to convert two electrically heated hot water tanks. In Thunder Bay, Ontario, natural gas is one third cheaper than the equivalent electrical energy. To my disbelief, the electrical utility salesperson tried to talk me into keeping my electric hot water tanks despite the difference in fuel costs!

As a home inspector, my curiosity was piqued and I began to dig deeper into the matter. I was surprised by my findings. The gas company's standard 40 gallon rental hot water tank has an energy factor (EF) of 58% as published in the Gas Appliance Manufacturers Association (GAMA) Consumer's Directory of Certified Efficiency Ratings. The energy factor represents the efficiency of the equipment, for comparative shopping, with other hot water tanks with similar features. EF ratings take into account the efficiency with which the fuel is converted into hot water, compared to how much heat is lost up the chimney, and it factors in the performance of the insulation around the tank.

The electric utility's standard 40 gallon rental hot water tank has an EF rating of 92%. Electricity has one third higher energy cost balanced out by a 34% better EF rating making the comparison between the two tanks appear equal. However, that is only part of the picture. I began to wonder how the EF rating considers the heat lost through the chimney of the gas appliance when the burner is not on. EF ratings only tell part of the story, as they are misleading when comparing the performance (as is often done) of natural draft gas hot water tanks with electric hot water tanks. The result can strongly favour gas hot water tanks because the EF ratings cannot factor what the gas association terms "envelope losses," due to different climatic conditions.

Envelope losses are defined as the energy lost up the chimney when the appliance is not burning. They occur during the entire heating and cooling season. Test conditions for EF ratings cannot factor in different climatic areas so the testing protocol for the rating assumes the same temperature inside and outside the building.

The EF rating is still valuable for comparing equipment with similar design features. For example, natural draft hot water tanks can be accurately compared using EF ratings with other natural draft hot water tanks because they will have similar envelope losses for any given climatic area. However, comparing hot water tanks with envelope losses with hot water tanks that have no envelope losses is not accurate: like electrically heated tanks or sealed combustion gas hot water tanks. This difference is not clearly laid out in GAMA's Directory. GAMA represents the gas industry and if there is confusion in the interpretation of EF ratings, in favour of inefficient gas appliances, it appears the gas association is slow to clarify the situation.

## Envelope Losses

How significant are envelope losses? The answer depends on the climate and the location of the hot water tank installation. In moderate and southern climates it is common for them to be found in unheated closets or garages. Naturally no envelope losses are associated with these installations. By contrast, where the winter is severe, there is no choice but to install the hot water tank inside the building envelope. In my rental property, which is a well air sealed and weatherstripped building in central Canada, there are significant envelope losses. According to the service department of the gas company, the mechanical room would require a five-inch passive make-up air vent, to prevent back drafting if I installed two natural draft hot water tanks. This five-inch diameter hole in the wall has to be added to the envelope losses. The existing electric hot water tanks don't need make up air because they have no chimney to back draft. In total the envelope losses for the new gas hot water tanks would equal:

2 x 4" diameter flue openings = 24 sq. in.
+5" diameter make-up air duct = 19 sq. in.
Total 43 sq. in.

The heating and cooling loss through this 43 sq. in. unobstructed opening in the building envelope is not accounted for in the EF ratings! By comparison electric tanks have no envelope losses.

Other factors in favour of electrically heated hot water tanks:

1) In Canada and the US, the gas codes allow insulating blankets on gas hot water tanks, but in Thunder Bay the gas company removes them as standard practice on their routine inspections. The explanation given is they are a safety concern as they may interfere with air flow to the burner or the flue.

2) On electric tanks it is possible to insulate the pipes for the first meter entering and exiting the tank where the largest convection losses are found. Often these pipes can't be insulated on gas tanks because insulation is not allowed within six inches of the flue.

3) An electric tank is more versatile to place because it is not restricted to a location near the chimney. It can be put near the point of use saving considerable standby losses in the pipes and wasted water waiting for things to heat up.

On the other side of the ledger, there are three notable benefits to gas hot water tanks:

1) They have faster recovery rates allowing the installation of smaller and cheaper tanks.

2) The temperature settings on gas hot water tanks are often more convenient which allows the homeowner to easily set it at an optimal temperature and turn it down while going on vacation.

3) If the electricity is generated by fossil fuels or nuclear power, then natural gas represents a cleaner environmental alternative.

Comparing rental hot water tanks in my area, the electric rental tank easily out performs the conventional gas rental tank. However, almost everyone rents gas hot water tanks, as I almost did, because they are so cheap to rent ($5.30 per/month), and gas is so much cheaper per BTU than electricity.

## High Performance Gas Hot Water Tanks

There are high performance gas hot water tanks with EF ratings as high as 86% (such as the Polaris) with no envelope losses. They are called direct vent or sealed combustion. This means the flame is sealed inside the tank and is supplied with its own combustion air so they can't be backdrafted. They have no envelope losses. When comparing sealed combustion gas hot water tanks to electrically heated tanks the EF ratings are meaningful. In this case, sealed combustion gas units with EF ratings at 86% have a performance shortfall of 5 - 7% when comparing EF ratings, but the gas tanks outperform their electric counterparts by the 30% in fuel costs. Sealed combustion tanks can be insulated, without risk of the insulation interfering with the draft, although it is probably not necessary. They are sidewall vented so they can be located conveniently near a wall or an existing chimney.

## Conclusion

So what did I choose? I replaced the two electric tanks and the forty-five year old inefficient boiler with a new Polaris combination heating and domestic hot water system. I anticipate a 25% annual savings in fuel for both systems for an average $300 a year for the next 20 years. Thank goodness for the electric utility salesperson who tried to talk me into keeping my electric tanks!

To the unwary consumer, EF ratings over simplify the shopping process, leading to choices that cost thousands of dollars in unnecessary fuel costs over the life of the equipment. It's like buying a $350 cell phone for twenty bucks by signing up for a long term package; beware of the service costs. An informed consumer will use EF ratings to compare hot water tanks with similar features and then factor in savings vs capital costs of better performing equipment.

*Bill Walker lives in Thunder Bay, Ontario, and is a home inspector and R-2000 design evaluator.*

# Technical Research Committee News

Canadian Home Builders' Association

## Carpet Yellowing

Not too long ago, we were dealing with carpet staining problems caused by air pressure differences. The characteristic patterns were dark stains, especially visible on light colour carpets, typically along the exterior wall. The staining was caused by fine particles of dust in the environment settling out at those points.

We are now receiving reports of carpet yellowing. It appears to be especially noticeable on light coloured carpets, but is not specific to any fibre type. The source appears to be BHT (butylated hydroxy toluene) a volatile additive used in urethane foam chip underlay. The BHT given off by the undercushion migrates through the carpet, and in the right conditions, can cause discolouration. The yellowing can be removed temporarily by the application of a citric acid solution.

The right conditions for the discolouration include:

- the presence of nitrogen and sulphur oxides (combustion gasses from heating and gas cooking systems that may be spilling back into the house);
- a lack of exposure to ultra violet light;
- high humidity levels;
- an alkaline environment on the carpet (which may happen after cleaning).

The carpet manufacturers say that this yellowing is not a carpet manufacturing defect, so they are not responsible. To avoid carpet yellowing, they suggest using carpet undercushion that does not contain BHT and that customers be alerted to potential discolouration from products containing this substance.

The undercushion manufacturers claim that many other products in the home also contain BHT. They say if the carpet is maintained at the appropriate pH level (on the acidic side) then yellowing will not take place. They claim that carpet yellowing is not a manufacturing defect, so as a result they are not responsible. Of course, if you avoid using carpets in the first place, you won't have this problem, and the carpet product manufacturers really won't be responsible.

If you have encountered carpet yellowing, let Ross Monsour at the TRC know. We'd like to know how widespread the problem is. Please provide as much detail as possible: type of problem, carpet type, location of the problem, etc. The more information we get, the easier it will be to encourage the carpet industry to pursue research into ways of avoiding this problem - perhaps by using alternate materials that won't be susceptible to yellowing.

## PVC Products

PVC is a material that is widely used today. It is very flexible, easy to use, durable, and can be used in many different products. However, the manufacture of PVC is a complex chemical process involving extensive use of chlorine, whose byproducts of industrial use include the formation of dioxins, which have been linked to a range of harmful health and environmental effects. Concerns have been raised by environmental groups and a move has started in Toronto to restrict or totally ban the use of PVC products. Some European communities have passed regulations against the use of PVC plumbing.

As is often the case, it is a big issue with few clear-cut answers. Every product has its environmental impacts and consequences. This is a question that merits analysis and careful consideration, and not a knee jerk reaction. The TRC will be monitoring the issue for its impact on the industry. If this issue is being discussed in your area, let us know.

## Telegraphing of Floor Underlays

We've reported previously about the telescoping of joints in floor underlays through finished flooring. Funding for the research has been provided by CMHC, Canadian Particleboard Association, Canadian Plywood Association, MAPI and MacMillan Bloedel.

The intent is to resolve the problem, and provide recommendations for avoiding it in the first place. Hopefully, results will be available later this year.

## Ice damming project

A research study investigating ice damming in roof attics is underway with CMHC's participation. It was spurred on by problems in some houses during the last couple of winters. Data was collected over the last winter.

Interestingly, where problems were noted, the attic temperature was warmer (by 5-7°C) than in those with no problems. It was also noted that most of the problems happened in interior units of row houses rather than single family dwellings or end units.

The data is now being analyzed, and a full report with recommendations should be available soon.

## APA Publications

APA - The Engineered Wood Association is the umbrella group for this industry. They are a valuable resource for product information and staff is available to deal with specific problems or issues of concern.

Two new publications are being completed, and should be available within the next month. One deals with structural insulated panels (also known as stressed skin panels). This will be a product guide containing key features and benefits and comparative R-values. The second is an OSB product guide, with full description of the product, its applications and span and performance ratings.

To get a full publication list from the APA's home page: Internet: *http://www.apawood.org or tel: 206-565-6600; fax 206-565-7265*

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

Canadian Home Builders' Association, Suite 200, 150 Laurier Ave. West, Ottawa, Ont. K1P 5J4
Tel: (613) 230-3060
Fax: (613) 232-8214



# Letter to the Editor

**Re: Radiant Heated Slab Performance: Slab Edge Heat Losses**
(Solplan Review, March 1996)

Sir,

I want to thank you for publishing Solplan Review. Every issue is intensely interesting and of use to my Building Inspection Service. Keep up the good work.

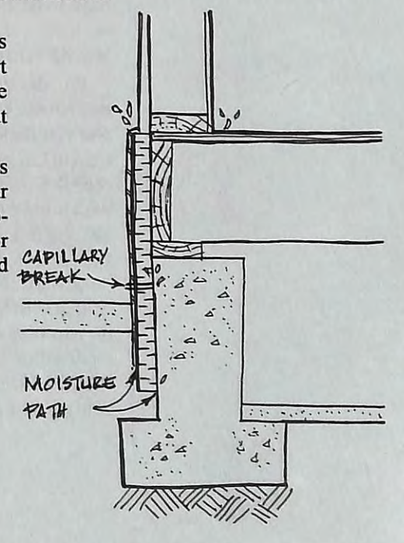
Your last issue (Solplan Review, No 67) illustrates two foundation sections, one insulated on the outside, one not. While I agree that perimeter insulation on the exterior of foundation walls is good I have run across a problem. The easiest way for me to describe this is with the sketch. The drawing is a section through the foundation of a home I inspected in Qualicum Beach, B.C. The home owner wanted to know why his kitchen floor was constantly wet. He had already spent thousands on an improved perimeter drain and a landscaped swale in the back yard, all in vain.

What I found was that, by a combination of capillary action and hydraulic pressure, water travelled between the foundation wall and the sheet metal. In the crawl space the edge joist was soaking wet. To solve the problem, I recommended a horizontal slot be cut through the sheet metal and insulation at grade level. This allowed the water to drain before it reached

the framing. Unfortunately this could not be done where the carport slab or sidewalk was higher than the top of the foundation wall (not without breaking concrete).

Qualicum Beach is known for its high water table and I have yet to hear of anyone else experiencing this problem. Perhaps there is little reason for general concern but I thought I would pass this along

Andrew Barker
Nanaimo, B.C.



# R-2000 Program Technical Requirement Adjustments

R-2000 Program News

*For Information on the R-2000 Program, contact your local program office, or call*
*1-800-387-2000*

The R-2000 Program has an energy consumption target as the principal yardstick by which compliance is measured. To provide meaningful comparisons, R-2000 design approval procedures have to follow uniform approach.

The technical requirements and design approval procedures have recently been fine-tuned. They reflect changes in materials and equipment available today, modified modeling techniques, and monitored results of various houses (including the advanced houses), to better reflect real conditions found in the field. The most significant adjustments are presented here.

## Energy Credit for Attached Garages

Attached, insulated garages offer a buffering and wind shielding effect on the rest of the house. The full shielding impact is still being evaluated, but enough information is available to know that a credit can be given.

As a result, for R-2000 purposes, common areas such as walls, overhanging floors and doors should be credited with an extra 15% R/RSI value. For example, if a common wall between an attached garage and house is R 20, it can be considered to be R 23. This means that a manual adjustment will have to be made in the HOT-2000 input.

## Ventilation Rates for Compliance

For design evaluation purposes, the total air change rate (which is the sum of natural air change and ventilation flow rate) must be modeled using CSA-F326 rates. However, the total need not exceed 0.5 air changes per hour. In smaller houses with a high room count it is possible that the air change rate may exceed the 0.5 air changes. In such a case, the ventilation rate may be adjusted downward so that it does not exceed 0.5 ach.

If all "indoor air quality options" are selected, for purposes of design evaluation, the house can be modeled at a ventilation air flow of 75% of the CSA-F326 ventilation capacity. This change recognizes that reducing the pollutant load by using low emission interior finish materials provides better indoor air quality, and the ventilation is targeted to the fresh air needs of occupants only.

## Heat Recovery Ventilators

Heat recovery ventilation performance is taken at a range of air flows and temperatures. For equivalent comparisons, the R-2000 program uses the power and efficiency ratings at airflows of 55 L/s (11 cfm) or 30 L/s (60 cfm) for smaller units. Some units may be modeled at either air flow rate.

To avoid confusion, a clarification has been provided: if the home being modeled requires a minimum ventilation rate capacity of 56 L/s or more, the HRV rating must be based on an airflow of 55 L/s. Otherwise, the HRV rate should be based on an airflow of 30 L/s.

## Carpeting

Acceptable carpeting now includes products labeled under the Canadian Carpet Institute's Green Label Program. The restriction of maximum carpet area to 50% of the interior floor area remains. (Wool or cotton area rugs and carpets that have latex free backing are exempt from carpet restrictions).

## Particleboard Underlay

All particleboard flooring underlay must meet the E-1 European standard or the ANSI A208.1-1993 Table B standard, or have all exposed surfaces sealed with an Environmental Choice approved sealer or a low toxicity sealer, or be prefinished.

## Ecologo Certified Products

Information about Ecologo products can be obtained from TerraChoice (613)-247-1900



# Avoiding Soils Problems

We know that a foundation is the key under pinning for a building. So why are there so many foundation problems? Soils related problems cost the Ontario New Home Warranty Program alone more than $500,000 annually. Direct builder repair costs (beyond ONHWP claims) are estimated at over $1.6 million per year.

Some problems may be due to the shortage of so-called 'good land', so there is an increasing tendency to use marginal or poor sites. Yet most problems arise from inadequate attention to preliminary site investigation and design.

To deal with these problems, the Ontario New Home Warranty Program has published *The Soils Manual for Home Builders*. It was developed to prevent soils-related problems in new home construction and avoid costly repairs.

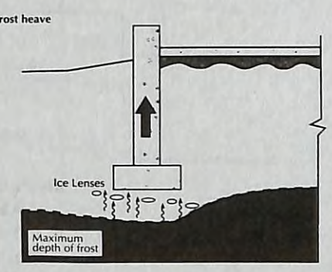
The manual is not a "how-to" book. It provides general information and checklists to assess soil conditions. It provides practical technical information to assess potential soils problems in your area and help prevent major structural defects. Guidelines for selecting a geotechnical consultant are also included.

## Frost -Related Problems

Frost-related problems are generated by freezing conditions that can cause significant heaving and damage to buildings.

Water expands about 10% by volume when it freezes, but this is not the primary cause of frost heaving. Rather, significant heaving happens when water is drawn from unfrozen areas into the frost zone resulting in the formation of ice lenses.

Conditions necessary for frost activity are:
frost susceptible soil;
available water;
freezing temperatures.




## Checklist for Structurally Sound Foundations

### Before construction

☑ Do an environmental site assessment to check for potential environmental problems.

☑ Obtain and review available soils information. Look for clues in the immediate areas especially if it is a new development with other construction in progress.

☑ Consult the Building Department and local warranty program officials about soils conditions. They may be hesitant to give definitive information, but you should get a good indication of the known conditions in the area in an "off the record" conversation.

☑ Do an investigation to learn the soil conditions.

☑ Select and seek advice from a qualified geotechnical consultant.

☑ Select a foundation design compatible with soil and groundwater conditions. Get advice from a structural consultant where appropriate.

☑ Train site staff (excavator, site supervisor, etc.) to recognize unusual conditions, to take prescribed approved remedial action, or to initiate investigations and seek advice from a qualified engineer.

☑ Obtain appropriate regulatory permits when needed.

☑ Assess the need for and scope of further investigation where warranted.

### During Construction

☑ Follow better building practices.

☑ Learn from the experience of others and avoid costly repairs.

☑ Carry out an appropriate site monitoring plan to enure a quality product.

☑ Carry out excavations according to the Occupational Health and Safety Act. Don't excavate below ground water table in granular soils (silts, sands, etc.) without dewatering.

☑ Employ good construction practices at all times when preparing foundation surfaces to receive concrete.

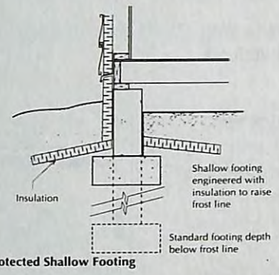
☑ Protect soil and foundations from freezing at all times during the construction period.

☑ Provide a free-draining backfill or draining membrane around foundation walls.

☑ Remember, settlement problems are most commonly caused by: footings placed on compressible soils, such as organic deposits and soft clays; random fill; improperly engineered fill; bases disturbed during construction; and frozen soil.

Common foundation problems can be grouped into several major categories:

- Frost related
- Settlement
- Leda and/or clay
- Fill/sand settlement
- Peat/organic soil settlement
- High water table



Frost Protected Shallow Footing

Soils particularly susceptible to frost action include silts, fine sands and sensitive clays.

## Preventing Frost Related Problems

Ensure footings are placed below the frost line. Frost penetration depths vary from region to region so you have to be aware of local experience and requirements.

An alternative to deep foundations is frost protected shallow foundations. Footings can be placed within the potential frost zone if properly insulated. The amount of insulation will depend on factors such as geographic location and type of insulation.

Ensure perimeter drains are installed properly, and install free-draining granular backfill next to both interior and exterior portions of the foundation walls and below the floor slab. Also, place a 'slip sheet' comprised of two layers of 6 mil poly on both the outside and inside foundation walls to prevent adhesion. The membrane sheets (such as the Platon system) or drainage fabrics and drain clad products are also very effective for this type of application. In the past winter, houses with this type of foundation protection did not experience any significant problems.

## High Water Table

There are few easy solutions to high water tables. The best way to avoid problems is to build above the highest water table. This requires reasonable knowledge of the water table levels and the potential for seasonal fluctuations.

Consult a hydrogeologist or geotechnical engineer and provide appropriately designed perimeter and underfloor perforated pipe and/or other permanent groundwater drainage system. Ultimately, you have to build a watertight basement that has sufficient load and strength to resist the hydrostatic pressures on the walls and floor. A structural engineer has to be consulted.

## Glacial Till

Glacial till refers to widely graded material (a mixture of boulders to clay sizes) deposited by glaciation. Generally these soils give good foundation support with few foundation problems.

Large boulders may require breaking up or heavy equipment to remove them.

Loosening of boulders at footing level during excavation can result in disturbance to the underlying soil as can precipitation and construction traffic.

## Bedrock

Bedrock provides good foundation support.

Except for the softer shales that can be excavated with heavy backhoes equipped with ripping teeth, excavation in bedrock usually involves drilling and blasting.

A problem with blasting is that it can loosen and disturb rock that, if not removed, can cause settlement problems.

Blasting requires competent trades, as it can result in deeper than required excavation.

A more serious problem can be differential settlement if the house footings are sitting only partly on rock and partly in soil.

In addition, footings and floor slabs for unheated areas above the frost line (e.g., garages) placed on rock may heave if water gets below the footings into cracks or crevices. The solution is to ensure that over-blasted or blast-disturbed zones are properly backfilled with concrete, or to lower the foundation level to prevent potential differential settlements.

Place a pad constructed of compacted granular soil or rock blastings between bedrock and foundation, and ensure proper drainage.

## Settlement: Leda and Other Soft Clays

Soft clays are low strength materials. One test is that these soils can be easily penetrated with a rod or other sharp object.

Special foundations and/or construction techniques may be required to work on these soils and advice should be obtained from a geotechnical consultant. Options include:

- Raft foundations
- Pile or caisson foundations
- Preload the site to consolidate weaker soils before construction.
- Excavate on slopes such that base heave and slope instability will not occur.
- Use equipment that reduces disturbance
- Provide ditches, sumps, etc., to divert precipitation
- Protect foundation level from freezing and thawing at all times
- Avoid planting trees near buildings and remove existing trees in these areas.



## Settlement: Random Fill

Random fill is soil/material which has been moved to its current location by man and/or machine and may be of unknown origin.

Potential problems include:

- Substantial and uneven settlements;
- Settlement can happen many years after construction;
- Health risks due to contaminants;
- Safety risks due to combustible gases.
- Special foundation solutions are required and exprt advice should be obtained. Solutions include:
- Removal of fill material
- Installation of piles or caissons;
- Structural slabs that can tolerate loss of support and that distribute settlements more evenly;
- Dynamic consolidation/compaction; and
- Gas barriers and/or venting.

## Selecting a Geotechnical Consultant

Getting good geotechnical advice can mean the difference between a successful project and one plagued by defects and costly repairs. The following qualifications should be evaluated:

- Check the record of the firm or individual
- Ensure they are currently licensed, and in good standing with the appropriate licensing body (provincial/state).
- Relevant experience in local area
- References from construction industry/ government agencies
- Status of liability insurance.

*Soils Manual for Home Builders* is a 3-ring binder format, avialable for $30.00 from the Ontario New Home Warranty Program,
Tel: 800-668-7504
Fax 416-449-9063

## EIFS: Exterior Insulating Finish System

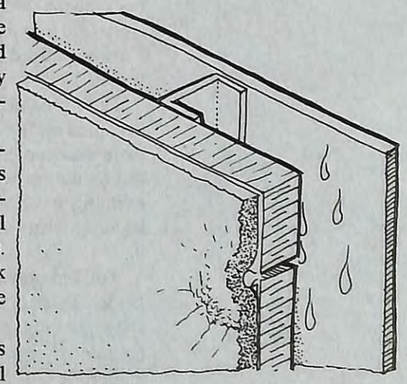
Exterior Insulating Finish System (EIFS) is a siding material for exterior walls. It is different from traditional portland cement plaster stucco as it is made from both synthetic and natural materials. It is used mostly in commercial and multi-family projects, but occasionally in single family houses.

EIFS is designed as a face-sealed barrier providing a weatherproof membrane. All water must shed at the outermost surface of the EIFS as water entering behind the base coat can enter the wall cavity. Water tight sealing around penetrations such as windows, doors, electrical outlets, vents, roofing, etc., is essential to maintaining the integrity of EIFS.

EIFS uses plastic foam board that is adhesively or mechanically fastened to the exterior wall sheathing. The base coat is applied directly to the surface of the plastic foam board along with a glass fiber mesh that is embedded during troweling The base coat is the rain barrier, while the finish coat provides the colour and texture. The base coat thickness can range from 1/16" to ¼".

Unfortunately experience shows that even standard construction doesn't always get detailed correctly when built. The results can be catastropic. Last issue we reported on a class action suit that has been started against EIFS manufacturers.

The National Association of Home Builders Research Centre investigated the moisture damage in a number of North Carolina houses finished with EIFS. The findings are interesting. Affected houses were not limited to any single builder, EIFS product manufacturer or window type.



It was noted that the only reliable method to assess a house's condition is to measure the moisture content of the exterior wall sheathing and structural members. A moisture meter and ice-pick probe were required to assess the moisture conditions.

Most EIFS construction details were developed for commercial structures, while residential win-

dow and door products and building elements are substantially different from those found in commercial buildings. Current flashing specifications by EIFS manufacturers do not adequately account for the variety of residential windows.

Moisture assessments of 209 houses conducted for the state building officials in North Carolina produced additional information on the performance of EIFS-sided houses. New houses, two to six years old, are experiencing structural damage due to excessive moisture within walls. The cause of moisture accumulation is rain water entering the walls due to a combination of factors including: improper sealing at joints around windows, doors and other penetrations; improperly sloped horizontal EIFS surfaces; inadequate flashing at roof lines, dormers, decks, fireplace chases; and window frames that leak into wall cavities.

A disturbing aspect is that moisture buildup and rotting could not be determined by visual inspection. A general impression based on a cursory visual inspection was that the houses' EIFS and interior finishes (gypsum) were in good shape. However, some of the houses had water-stained walls and ceilings but delamination of the plastic foam board had not occurred. Prolonged moisture buildup occurs when leaks go unnoticed, especially when water does not travel directly into the house.

When water gains access through sealant-joints and flashing, the system can also retain water, like a bowl, especially when EIFS is on both sides of a wall. In one house, the water had collected in EIFS-covered arches supporting a deck. Water poured out for five minutes from moisture probe holes!

Moisture problems in some walls were attributed to leaks associated with roof drainage and flashing, so the systems to use should allow for that, by having some redundant system built in. That is why rain screen exterior siding systems should be used.

Remedial action must be determined on a house-by-house basis since there is no single cause of leakage or recommendation for repair.

The moral of the story? Careful attention to detail is a MUST! Maybe Murphy is king, and if something can go wrong, it probably will. ☼

## Advanced House Performance Results

Preliminary monitoring results from the Advanced Houses are now available.

The objectives of the technical requirements were to meet an energy target about half that of R-2000 houses, reduce water use, improve indoor environment (air quality, thermal comfort and noise reduction), and ecomanagement. After the open house period that lasted a year, the houses were sold and intensive monitoring took place.

How well did the various houses do to meet their targets?

Unfortunately, only five of the houses were occupied during the full monitoring period; three were unoccupied. The data from the unoccupied houses only provides an indication of how well the building envelope performs. Without residents, lighting, water and appliance loads are not available.

Total energy consumption targets, which included lights and appliances and also water and space heating, were an average of 57 kWh/m² (compared with an R-2000 budget of about 122 kWh/m²).

Measured total energy consumption averaged 85 kWh/m², which compares favourably with equivalent measured values of 209 kWh/m² in a group of R-2000 houses.

Generally, energy use for lights and appliances is significantly above the target, and it accounts for the variation from the calculated values. Space and domestic hot water energy consumption is generally close to the target for most of the houses. The unoccupied houses generally were near or under the predicted budgeted energy use, but that was without the resident imposed loads for water heating or appliance energy use.

One interesting test done at the B.C. Advanced house shows the value of a well-insulated building with passive solar gains. A 'cool down' test measured the effect of turning of the space heat off for a week. After 5 days, the indoor temperature dropped from 20.7° C to 14.7° C (the outdoor temperature during the period averaged 5.6° C). The modest solar gains available during the period raised indoor temperatures by about 1° C.



## Coming Events

June 25-25, 1996
Green Building Materials '96 A forum for manufacturers, specifiers, architects and builders. Technical presentations as well as product displays and discussion forums focusing on "green" products (and what it may mean). For information, contact:
Dr. Charles Kibert, Centre for Construction and Environment, University of Florida, Gainsville, FL. Tel 904-392-7502; Fax 904-392-9606.

22-24 August, 1996
HRAI Annual National Business Conference, Whistler, B.C.
Information: HRAI, Tel 1-800-267-2231; Fax 905-602-1197

25-31 August, 1996
Profiting from Energy Efficiency, Pacific Grove, CA
1996 ACEEE Summer Study on Energy Efficiency in Buildings.
Information: Tel: 202-429-8873; Fax 202-429-2248

9 - 11 September, 1996
Use of Recycled Wood and Paper in Building Applications, Madison, Wisconsin
Information: Tel: 608-231-1361; Fax 608-231-2152

17 - 20 September, 1996
17th AIVC Annual Conference "Optimum Ventilation and Air Flow in Buildings", Gothenburg, Sweden. Contact: Rhona Vickers, AIVC, Sovereign Court, Univ of Warwick Science Park, Coventry CV4 7EZ, England
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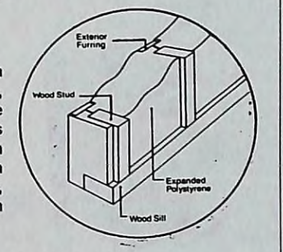


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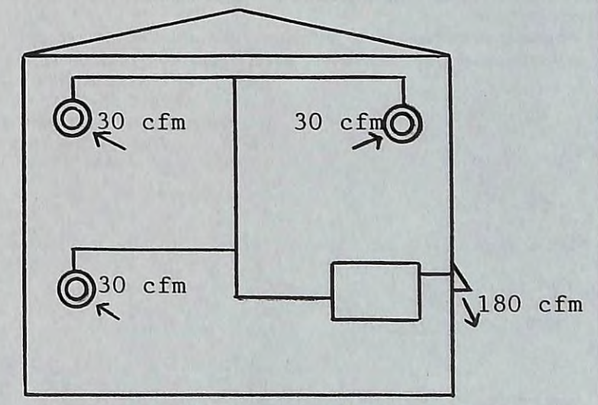


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